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(54) **Stabilized oil-in-water emulsions.**

(57) The present invention relates to stabilized, concentrated or diluted emulsions of the oil-in-water (O/W) type providing pesticidal activity and their use. More specifically the invention relates to stable O/W macroemulsions which comprise one or more pesticidal active ingredients in both the oil and water phases, wherein the oily phase is emulsified or dispersed in the water phase by an emulsifying system ; and wherein the emulsions are further stabilized by a solid dispersing agent, namely titanium dioxide, which maintains or improves the emulsion stability. It also relates to a suspoemulsion obtained by milling the said emulsion with an additional solid pesticidal substance.

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The present invention relates to stabilized, concentrated or diluted emulsions of the oil-in-water (O/W) type providing pesticidal activity and use. More specifically the invention relates to stable O/W macroemulsions which comprise one or more pesticidal active ingredients in both the oil and water phases, wherein the oily phase is emulsified or dispersed in the water phase by an emulsifying system; and wherein the emulsions are further stabilized by a solid dispersing agent, namely titanium dioxide, which maintains or improves the emulsion stability. It also relates to a suspoemulsion obtained by milling the said emulsion whith an additional solid pesticidal substance.

In general, an emulsion is the result of dispersing one immiscible liquid in another, and is made relatively stable by means of one or more emulsifying agents which are usually surface-active agents.

The result is a "significantly stable" suspension of droplet particles of a certain size of a liquid homogeneously dispersed within a second immiscible liquid, defined as the continuous phase. The phase "significantly stable" is a relative one meaning relative to the intended use of the emulsion and to the relative ability of one emulsifying system vs. another to stabilize a given system of various differing components, which are additionally subject to various physical and chemical conditions or factors.

The basic factor in the stability or instability of an emulsion is the degree of interfacial tension (i.e., free energy) between the droplets of the dispersed liquid and the other continuous liquid phase. A high interfacial tension makes an emulsion inherently (basically) thermodynamically unstable.

The purpose of the emulsifying (or dispersing) agent, which is usually a surface-active agent, is to interact at the interface between the dispersed liquid droplets and the other continuous liquid phase. It thus functions to stabilize a basically unstable system by adsorption at the liquid/liquid interface as an oriented interfacial film. The result is a reduction in interfacial tension and a decrease in the rate of coalescence of the dispersed liquid particles by forming mechanical, steric and/or electrical barriers around them.

Emulsions may be categorized in two ways: first by the size of the dispersed particles (that is to say micro- vs. macroemulsions) and second by the nature of which phase forms the dispersed droplets and which is the continuous phase (that is to say oil-in-water, O/W, vs. water-in-oil, W/O.

Both O/W and W/O micro- and macroemulsions are used for pesticidal compositions, the preference depending upon the system components and the required stability criteria. Macroemulsions generally have a dispersed droplet particle size from about 0.2 to about 50 microns. However, they are basically more unstable than a microemulsion (<0.2 microns), generally due to a wider particle size distribution whereby there is a higher tendency of larger droplets to coalesce with smaller ones and thus more readily break the emulsion.

The choice between O/W and W/O emulsions also depends upon the system components and the required stability criteria. An O/W is generally produced by emulsifying agents which are more soluble in the water than in the oil phase. The reverse generally provides W/O emulsions.

While the use of emulsions is frequently advantageous, their preparation and maintaining their stability frequently involves substantial experimentation (trial and error) and even then the compositions may have only limited stability in either their concentrated form or in end-use diluted compositions.

The emulsifying/dispersing system thus plays a key role in providing stable emulsions, but it is frequently complex and not easy to identify because of the required optimization of many different properties/characteristics such as the following:

- There must be good surface activity to produce a low interfacial tension in the system used. The emulsifier must have the tendency to migrate to the interface rather than remain dissolved in either bulk phase.
- The emulsifier must form, by itself or with other adsorbed molecules, a condensed lateral interfacial film.
- The emulsifier must migrate to the interface at sufficient rate to reduce the interfacial tension to a low value during the time the emulsion is produced.
- The emulsifier is best a mixture of a preferentially oil-soluble surface-active agent and a preferentially water-soluble one. This frequently produces a better and more stable emulsion.
- An emulsifier that is preferentially water soluble (generally HLB of 8-18) will generally produce lower interfacial tension (i. e. contact angle <90°) at the water interface and produce O/W emulsions.

Hydrophilic groups in the interfacial film provide a barrier to coalescence of oil droplets in O/W emulsions.

- A suitable emulsifier for an O/W emulsion should give a PIT (phase inversion temperature) of 20-60°C higher than the normal storage temperature of the emulsion.
- An emulsifier which inhibits or reduces components of the dispersed droplets from wetting the interfacial film (i.e., high contact angle between emulsifier in the film and the components in the droplet) will provide droplets that will not easily coalesce and thus stabilize the emulsion.

The above properties of a good emulsifying/dispersing system will thus determine the relative importance and influence of the following factors which are generally recognized by one skilled in the art to be important in determining emulsion stability (the resistance of emulsions to coalescence of their dispersed droplets - i.e., "resistance to breaking the emulsion").

– The Physical Nature of Interfacial Film - mechanical strength and intermolecular forces.

– The Existence of Electrical or Steric Barrier on the Droplets - significant in O/W emulsions.

– The Viscosity of the Continuous Phase - reduced diffusion reduces droplet collision and thus reduces coalescense.

– The Size Distribution of the Droplets - wider size distribution, especially in macroemulsions, allows larger droplets to coalesce at the expense of smaller droplets.

– The Phase Volume Ratios - basic instability, especially in macroemulsions, tends to increase as the volume of the dispersed phase increases and the continuous phase decreases.

– The Temperature - variation of temperature affects the nature and viscosity of the interfacial film/tension and can inverse or break the emulsion.

From the above discussion, it is thus readily obvious that even for one skilled in the art of emulsion technology, particularly in the area of pesticidal emulsions, the solutions frequently remain complex and each situation may encounter its own unique set of problems which are not necessarily limited to just the stability of the emulsion. Other factors or problems that must be considered include, for example:

– Compositions containing more than one pesticidal substance, which differ significantly in chemical and physical properties, in particular where one is soluble in the lipophilic (oil) phase and the other is soluble in the water phase.

– The need for improved overall safety characteristics of the composition, for example, by reducing/eliminating organic solvents which are frequently flammable, corrosive or toxic to living systems and are of environmental concern.

– Instability resulting during ready to use aqueous dilution of initially stable concentrated emulsions.

For Various reasons, including those aspects mentioned above, one may frequently prefer an O/W emulsion. Thus in the specific case of O/W emulsions for pesticidal use where the dispersed oily phase contains a lipophilic pesticidal substance, one or more solvents may be required in the case where this lipophilic substance is naturally in the solid state at the temperature or in the temperature region under consideration. On the other hand, the dispersing phase consists of water, optionally containing a water-soluble pesticidal substance, and a variety of other additives, specifically including surface-active agent(s) which are responsible for the interface between the two phases.

This basic outline, however, is far from enabling to a person skilled in the art to solve all the problems linked with the production of such emulsions in the case of each pesticide.

It is known, in fact, that preformed emulsions of pesticidal lipophilic substances in aqueous media tend to break when, as a result of a temperature variation, these substances change from the solid state into the liquid state, to return into the solid state (solidifying/ melting).

This disadvantage is particularly detrimental when the melting points of such pesticidal substances are in the range of temperature variation within which the said substance is stored, because this makes the composition unsuitable for later use.

Similarly, it is known that in the case of pesticidal products which have a melting point below 100°C it is very difficult to produce an aqueous suspension, because they begin to change state well before their melting point, and this consequently makes them difficult to mill. This is the case especially in hot countries, or in the summer in temperate regions.

These situations are further complicated when, in addition to the pesticidal substance in the oil phase, it is also desired that the composition contains another pesticidal substance soluble in the aqueous phase. This problem, in part, may result due to the tendency of the emulsion to break down because the water soluble pesticide may in itself behave as a surface-active agent, especially in the case of water soluble salts of these compounds. Their solubility in the aqueous phase then causes problems at the interfacial film between the oil and water phases. The result is that the dispersed oil droplet phase has an increased tendency to freely migrate/diffuse into the aqueous phase which leads to coalescence of the oil droplets and instability of the emulsion. Other aspects of the problem may include what is known as the salting out effect caused by high concentration of ions, especially inorganic ions, in the aqueous phase which causes the oil phase to separate out.

While it is known that O/W emulsions can be produced with some very specific systems where a pesticidal substance is only in the oil phase or optionally both the oil and water phases each contain a pesticidal substance, for example, as described in US Patents 4,810,279; 4.822,405; 3,873.689; 4,594,096; or in EP 70702 (apparently corresponding to US 4,440,562), the technology is still unpredictable. This unpredictability may be seen, for example, in: US 4,853,026 which describes an initially formed O/W emulsion which surprisingly and rapidly inverts to W/O; GB 2,022,418A which only provides a W/O emulsion; EP 289,909A2, in which the examples demonstrate the critical nature and concentration of all the composition components - even slight changes outside the optimum concentrations produced a number of unstable O/W emulsions; or GB 2,082,914A which specifies that a very narrow size distribution is required for the dispersed oil droplet particles.

While the above emulsions, which unpredictably may or may not be stable, utilize well known and recognized ionic or non-ionic emulsifying/dispersing agents, which are surface-active agents, other persons have attempted by less known techniques to provide emulsification by solid powders. These may be present with or without other normal surface-active emulsifiers. Such powders may alternatively be referred to as dispersing or stabilizing agents. For example, unpredictably O/W or W/O emulsions are produced depending upon the interfacial contact angle provided by a specific powder, the nature of the oil and water components, the type of surface-active agents present, the nature of the surface of the powder, and the pH of the system, etc. Schulman et al., Kolloid-Z. 136, 107- 119 (1954), reports emulsions stabilized by barium sulfate or co-precipitated barium sulfate-zinc sulfide powders. Scarlett et al., J. Phys. Chem., 31, 1566-1571 (1927) describes emulsification by a number of different powders including glass, copper, pyrite, zinc, charcoal and mercuric iodide. The type of emulsion produced, W/O or O/W, is highly variable and neither of these references describes compositions containing pesticidal substances.

In general, metals and metal oxides, including titanium dioxide, are known to be used in some types of pesticidal/agricultural formulations, for example as described in: DT 3004-010; DT 3005-016; DT 2804-141; J5 5020-750; J6 2004-210A; US 4,493,725; J5 8177-902A; J5 6086-105; or J5 6152-401. These compositions are, however, predominantly granular solids, powders, pastes or creams. In these applications, the function of the inorganic minerals, including that of titanium dioxide is typically as a pigment, a support or carrier, a controlled release agent, an anticaking agent, an antistatic agent, or an acid neutralizing agent.

Only in a few instances has titanium dioxide been disclosed for use in liquid pesticidal compositions, including emulsions. Here again, the purpose of titanium dioxide is usually as a pigment or a support. For example, US 3,873,689, as mentioned previously discloses O/W emulsions. These emulsions contain inert white pigments, such as titanium dioxide, which are typically used at high concentration levels to provide a marking effect during spraying of end-use compositions.

While GB 213,116A does not describe emulsions for agrochemical/pesticidal uses, it does describe pharmaceutical, cosmetic or food emulsions which are W/O and which are stabilized by hydrophobic surface modified metals or metal oxides. The reference broadly discloses metal oxides including that of titanium, but only exemplifies silicas. The examples show that these hydrophobic surface modified suspending agents produce only W/O emulsions. However, on the other hand, while non-surface modified hydrophilic agents initially gave O/W emulsions, these were not stable and rapidly separated into three phases.

Furthermore, while EP 342,134/So. Af. 89-3391, corresponding to copending USSN 07/526,776, filed May 17, 1990, describes O/W emulsions which are stabilized by a titanium dioxide dispersing agent, these emulsions contain only a lipophilic soluble pesticidal substance. These emulsions don't contain any aqueous soluble pesticidal substances, which as discussed above, have a tendency to lead to unstable emulsions.

It is clearly obvious from the above that this emulsion technology is very complex, very specific and thus very unpredictable. Even extensive experimentation may not solve the numerous problems which exist and may not identify a simple uniform (widely applicable) solution to the problem(s), irrespective of the nature and concentration of the pesticidal substances, other adjuvants, processing conditions, and storage and application conditions of both concentrated and ready to use diluted O/W emulsions.

In its most general form, the invention relates to a stabilized pesticidal emulsion of the oil-in-water type (O/W), comprising:

a. an oil phase containing a lipophilic pesticidal substance, optionally dissolved in an organic solvent;
b. a water phase containing a compatible water-soluble pesticidal substance;
c. an emulsifying system capable of emulsifying or dispersing the oily phase in the water phase; and
d. a stabilizing or dispersing agent comprising titanium dioxide in an effective amount to further maintain or improve the stability of the emulsion.

More specifically the invention relates to stable O/W macroemulsions which comprise one or more pesticidal active ingredients in both the oil and water phases; and wherein said emulsions are further stabilized by a very fine solid dispersing agent, namely titanium dioxide. In particular, titanium dioxide is preferred to have a substantially hydrophilic surface and be of a uniformly fine particle size <1 microns, preferably between about 0.2-0.3 microns. It is further preferred that the size of the titanium dioxide particles be significantly smaller than the average diameter of the dispersed oil-phase droplets in the macroemulsion.

The invention also relates to a suspoemulsion obtained by milling the said emulsion with an additional solid pesticidal substance.

The invention also preferably relates to pesticidal O/W emulsions as described above comprising:

a. an oil phase confining a lipophilic pesticidal substance which has a melting point below 100°C, optionally whereby the substance is dissolved in an organic solvent;
b. a water phase containing a compatible water-soluble pesticidal substance;
c. an emulsifying system capable of emulsifying or dispersing the oily phase in the water phase; and

d. a stabilizing or dispersing agent comprising titanium dioxide in an effective amount to further maintain or improve the stability of the emulsion.

Furthermore, the invention also preferably relates to pesticidal O/W emulsions as described above comprising:

a. an oil phase containing a lipophilic pesticidal substance which has a melting point situated within the range of temperature variation to which the said substance is subjected, during storage or preparation of the emulsion, optionally whereby the substance is dissolved in an organic solvent;

b. a water phase containing a compatible water-soluble pesticidal substance;

c. an emulsifying system capable of emulsifying or dispersing the oily phase in the water phase; and

d. a stabilizing or dispersing agent comprising titanium dioxide in an effective amount to further maintain or improve the stability of the emulsion.

Generally the range of temperature variation described above is usually between about -20°C and about +60°C.

Thus, an object of the present invention is to provide an oil-in-water (O/W) pesticidal emulsion exhibiting great stability.

A second object is to provide safer water based emulsion compositions by reducing or eliminating flammable and toxic organic solvents which may be detrimental to living species and to the environment.

A third object is to provide more easily prepared and convenient O/W pesticidal macroemulsions which, although having a wide particle size distribution which tends to give instability, are readily and easily stabilized against oil-phase droplet coalescence.

A fourth object is to provide O/W pesticidal macroemulsions which reduce or inhibit hydrolysis of hydrolytically unstable pesticidal substances, particularly esters, which are contained within the dispersed oil phase droplets.

A fifth object is to provide concentrated O/W pesticidal macroemulsions which are readily diluted with water for end-use application while maintaining good emulsion stability.

A sixth object is provide a stable pesticidal O/W macroemulsion which has additional or improved stabilization due to the presence of a very fine powdered stabilizing/dispersing agent which is insoluble in the system, highly inert, significantly reduces interfacial tension between the phases, and inhibits coalescence of oil-phase droplets.

A seventh object is to provide a stable O/W pesticidal macroemulsion which, besides having a pesticidal substance in the oil phase, additionally has dissolved in the aqueous phase a pesticidal substance, which may in the form of a salt thereof have a tendency to destabilize the emulsion.

Another object of the present invention is to stabilize an O/W emulsion containing a lipophilic pesticidal substance or a mixture of lipophilic pesticidal substances whose melting point is within the range of variation of preparation or storage temperature of the emulsion. More particularly, the present invention provides liquid, stable, improved compositions with lipophilic pesticidal products which have a melting point below 100°C.

These and other objects of the present invention shall become readily apparent from the detailed description of the present invention.

The oil-in-water (O/W) emulsions, preferably macroemulsions with an average oil phase droplet size greater than about 1 micron, advantageously comprise, in grams/litre:

a	a lipophilic pesticidal substance(s)	100 to 800	oily phase
b.	an organic solvent	0 to 350	
c.	a hydrophobic surface-active emulsifying agent	0 to 100	
d.	a hydrophilic surface-active emulsifying agent	20 to 60	
e.	a compatible water soluble pesticidal substance(s)	20 to 600	

f.	a titanium dioxide-based dispersing or stabilizing agent	1 to 100

and

g.	water	balance to 1,000 .

It has been found, quite unexpectedly, that the addition of small amounts of titanium dioxide, as a very fine solid/powdered dispersing agent, greatly improves the stability of oil-in-water emulsions.

Titanium dioxide is preferably present in a proportion of about 1 g/ l to about 100 g/ l of the emulsion, advantageously about 5 g/ l to about 50 g/l, and preferably about 10 g/l to about 20 g/l in normal oil-in-water emulsions and about 10 g/l to about 30 g/l in suspoemulsions (suspended solid active ingredient in an oil-in-water emulsion of other active ingredients).

It is known that natural titanium dioxide crystallizes in three allotropic varieties: rutile, anatase and brookite, the former two being particularly preferred especially wherein they have a substantially hydrophilic surface. These three varieties are suitable within the scope of the present invention, wherein the form of titanium dioxide has an average particle size between about 0.1 and 1.0 microns, preferably between about 0.2 and about 0.3 microns. It is further preferred that the average particle size of titanium dioxide be significantly smaller (i.e., from about 2% to about 50%) in comparison to the average size of the dispersed oil droplets in the oil-in-water emulsions of the present invention.

Titanium oxide of the type described is available from the French company Thann et Mulhouse and in the United States from E.I. duPont de Nemours and Co. (Inc.).

The following are some of the characteristics or properties of titanium dioxide, functioning as a dispersing agent, which are believed to be responsible for the unexpectedly improved stability of the O/W pesticidal macroemulsions of the present invention.

1. Totally insoluble in both water and oil phases.
2. Migrates to and remains at the interface between the liquids and forms a coherent thin film around dispersed oil droplets, preventing the thinning of the liquid film between the dispersed droplets.
3. May be chemically/physically treated with surface modifiers to provide improved performance properties such as dispersibility in water. Provides ability to adsorb emulsifying agents and thus add to the stability of the interfacial film surrounding the dispersed droplets.
4. Neither to strongly hydrophilic nor too strongly hydrophobic, but preferably more hydrophilic, and thus not easily wetted by either oil or water phase.
5. Provides an appropriate finite contact angle at the liquid/liquid interface, preferably slightly less than 90°, which reduces the interfacial tension and favors an O/W emulsion.
6. Presents a barrier to contact of dispersed oil droplets, thus prevents/inhibits coalescence of the droplets and provides emulsion stability.
7. Very small average particle size (~0.1-1 micron, preferred 0.2-0.3 micron) in comparison to the average oil droplet particle size (~1-8 micron average).
8. Excellent chemical and physical stability. Retains very small particle size without clumping and maintains suspension. Flocculation/agglomeration of TiO_2 particles in fluid systems typically forms only loose clumps which are easily broken and redispersed under only moderate shear.
9. Low concentration, preferably 1-2%, in O/W concentrated emulsions, readily provides stable macroemulsions over broad temperature ranges and for extended time periods.
10. Further dilutions of the concentrated O/W emulsions with water for end-product use (e.g. in spray tank) continue to maintain emulsion stability.
11. Provides a protective film on dispersed oil droplets, containing active pesticidal ingredients, to prevent-/inhibit agglomeration or crystal growth of small particles into larger particles which may arise during temperature changes and/or freeze-thaw cycles of the emulsion on storage.
12. Is widely applicable/useable in numerous O/W emulsions generally irrespective of the nature of the pesticidal active component(s) which may be contained in the oil phase or contained in both the oil and in the water phase.

The pesticidal O/W emulsions, especially macroemulsions, of the invention, as described above, are of the type where separate pesticidal substances are contained in each of the oil and water phases. A pesticide means either an active substance or a mixture, for example binary or ternary, of active substances. These pesticidal substances may exist as optical, geometric or stereoisomers, etc. insecticides, fungicides, herbicides,

plant growth regulators, nematicides, rodenticides and repellent products may be mentioned, no limitation being implied.

Regarding the lipophilic pesticidal substance referred to above, the melting point is preferably less than 100°C and is generally in the range of storage temperatures which can usually vary between about -20° and about +60°C. Exceptional conditions may, of course, extend above or below the range defined above, but it should be understood that the formulations according to one of the preferred alternative forms of the invention can be used in all the cases where the temperature variation causes a change of state in the pesticide.

If there is a mixture of lipophilic substances, such a mixture may exhibit a eutectic point, well known in physical chemistry. Also, in the case of these mixtures, the invention will preferably relate to those whose eutectic point is below 100°C or those whose eutectic point is situated within the temperature variation region, as defined above. Furthermore, however, the invention also relates to mixtures without a eutectic point, in which at least one of the substances corresponds to the above definition.

Lipophilic pesticidal substances are numerous and diverse and it is not part of the applicant's intention to limit the invention to any category of pesticide whatever, except that, in the case of one of the preferred alternative forms of the invention, they must meet the criteria defined above, namely have a melting point below 100°C or a melting point within the region of temperature variation as indicated above.

Among these lipophilic pesticidal substances with melting points below about 100°C, there may be mentioned phosalone, the aclonifen-oxadiazon mixture, aclonifen-linuron, aclonifen-bifenox, bifenox, acephate, aclonifen, alachlor, aldicarb, amethryn, aminocarb, amitraz, azamethiphos, azinphos-ethyl, azinphos-methyl, aziprotryne, benolaxyl, benfluralin, bensulide, bensultap, benzoximate, benzoylprop-ethyl, bifenthrin, binopacryl, bromophos, bromo-propylate, bromoxynil esters, bupirimate, buthiobate, butocarboxim, carboxin, chlorbufam, chlordimeform, chlorfenson, chlormephos, chlorobenzilate, flurochloridone, chloropropylate, chlorphoxim, chlorpropham, chlorpyrifos, chlorpyrifos-methyl, cloethocarb, cyanophos, cycloate, cycloxydim, cyfluthrin, demethon-S-methyl, desmetryn, dialifos, diazinon, diclofop, dicofol, diethatyl, dimethachlor, dimethomethryn, dimethoate, dinobuton, dinoseb, dioxabenzofos, DNOC (2-methyl-4,6-dinitrophenol), EPN (O-ethyl O-(4-nitrophenyl)-phenylphosphonothioate), etaconazole, ethalfluralin, ethiofencarb, ethofumesate, famphur, fenamiphos, fenitropan, fenobucarb, fenothiocarb, fenoxaprop, fenoxycarb, fenpropathrin, fenson, flanuprop, fluchloralin, fluorodifen, fluoroglycofen, flurecol, fluroxypyr, formothion, furolaxyl, furmecyclox, haloxyfop, heptenophos, hymexazol, iodofenphos, ioxynil esters, isoprothiolane, linuron, metalaxyl, metazachlor, methamidophos, methidathion, methopotryne, metolcarb, monalide, monocrotophos, monolinuron, myclobutanil, napropamide, nitrapyrin, nitrofen, nitrothalisopropyl, oxabetrinil, oxadiazon, oxyfluorfen, parathion-methyl, penconazole, pendimethalin, pentanochlor, phenthoate, phosfolan, phosmet, piproctanil, pirimicarb, prochloraz, profluralin, promecarb, prometon, propachlor, propamocarb, propanil, propetamphos, propham, propoxur, propthoate, pyrazophos, pyridate, quinalphos, quizalofop, resmethrin, secbumeton, simetryn, tebutan, tefluthrin, temephos, tetramethrin, tetrasul, thiofanox, tolciofos-methyl, triadimefon, trichlorfon, tridiphane, triflumizole, trifluralin, and xylylcarb.

Other pesticides with melting points below 100°C which can advantageously be used in the compositions of this invention include the various esters of the class of phenoxyalkanoic acids. These include for example:

2.4-D	(2,4-dichlorophenoxy) acetic acid esters;
2.4-DB	4-(2,4-dichlorophenoxy) butyric acid esters;
2,4-DB	2-(2,4-dichlorophenoxy) propionic acid esters and their optical isomers;
2,4-DP (BEE)	2-(2,4-dichlorophenoxy)propionic acid butoxy ethyl ester;
MCPA	(4-chloro-2-methylphenoxy) acetic acid esters;
MCPB	4-(4-chloro-2-methylphenoxy) butyric acid esters; or
Mecoprop	2-(4-chloro-2-methylphenoxy) propionic acid esters and their optical isomers.

The invention has been found to be particularly advantageous for those lipophilic pesticidal active ingredients which may be further subject to hydrolytic instability in their compositions during prolonged storage or on exposure to elevated temperatures. Amongst those compounds which may be mentioned are phenoxyalkanoic acid esters, other carboxylic acid esters, organophosphorous esters, and esters of phenols. In the latter case, the invention has been found to be partucularly advantageous for bromoxynil esters, especially bromoxynil C_1-C_8 alkanoates by themselves or mixed, such as bromoxynil butanoate, heptanoate and octanoate, which are compounds that are well known in the art. The concentration of bromoxynil esters will advantageously vary between about 100 g/l and about 600 g/l, based on bromoxynil phenol, depending on the esters or ester mixtures employed.

If the lipophilic pesticidal substance requires it, which may be the case, it is dissolved in a suitable organic solvent. Within the scope of the present invention, the term solvent covers both a single solvent and a mixture of several solvents. The particular organic solvent is obviously not critical and any solvent or solvent mixture whatever may be employed which suitably dissolves the lipophilic pesticidal substance.

Among solvents there may be mentioned commercial solvents of aromatic/paraffinic nature, such as SOLVESSOS or kerosenes, or solvents of an alkylaromatic, aliphatic or cycloaliphatic type, or else natural vegetable oils such as rape oil or modified oils. There may also be mentioned alcohols such as cyclohexanol, ketones such as cyclohexanone and acetophenone, chlorinated solvents such as carbon tetrachloride or chloroform, dimethylformamide and dimethyl sulphoxide.

It may be generally preferable to employ a pair of solvents, one being rather hydrophobic, such as the hydrocarbon solvents mentioned above, and the other being rather hydrophilic, such as the solvents containing functional groups referred to above. The balance between the hydrophobic solvent and the hydrophilic solvent is obviously a function of the nature of the pesticide or of the pesticide mixture.

For those pesticidal substances which are compatible, water soluble and contained in the aqueous phase of the O/W emulsions of this invention, they may be soluble in their normally occurring form or as the result of base or acid addition salts thereof. By the term compatible, it is meant an agronomically acceptable pesticidal substance(s) which does not adversely interact physically or chemically with the other components of composition. These water soluble pesticidal substances or salts thereof, typically present in amounts from about 20 to about 600 g/l, may include, for example:

Acephate

Acrolein

Acifluorfen

Alloxydim

Ametryn

Amiben

Amitrole

Ammonium sulphamate (AMS)

Arsenious acid

Asulam

Benazolin

Bentazone

Benzsulfuron

Bilanafos

Borax

Bordeaux mixture

Bromacil

Bromoxynil phenol

Butoxycarboxim

(RS)-sec-Butylamine

Carbendazim

Cartap

Chloramben

Chlorfenac

Chlorimuron

Chlormequat

Chloroacetic acid

Chlorphonium

Chlorsulfuron

Clopyralid

Cloprop

Cloxyfonac

2,4-D (2,4-dichlorophenoxy) acetic acid

2,4-DB 4-(2,4-dichlorophenoxy) butyric acid

2,4-DES 2-(2,4-dichlorophenoxy)-ethyl hydrogen sulphate

Dalapon

Daminozide

Demeton-S-methylsulphon

Dicamba

Dichlorophen

Dichlorprop (2,4-DP)

Dicrotophos

Difenzoquat

Dikegulac
Dimethipin
Dimethirimol
Dimethylarsinic acid
4,6-Dinitro-o-cresol (DNOC)
Dinoseb
Dinoterb
Diquat
Dodine
Enothal
Etacelasil
Etephon
Fenaminosulf
Fenoprop
Fluoroacetamide
Flupropanate
Fomesafen
Formaldehyde
Formetanate
Fosamine
Fosetyl
Glufosinate
Glyphosate
Guazatine
Hexazinone
2-Hydrazinoethanol
Hydrogen cyanide
8-Hydroxyquinoline Sulfate
Hymexazol
Imazapyr
Imazaquin
Imazethapyn
Imazilil
Iminoctadine
Indol-3-ylacetic acid
4-Indol-3-ylbutyric acid
Ioxynil phenol
Maleic hydrazide
MCPA (4-chloro-o-tolyloxy)-acetic acid
MCPB 4-(4-chloro-o-tolyloxy)-butyric acid
Mecoprop
Mefluidide
Mepiquat
Mercuric chloride
Metham
Methamidophos
Methomyl
Methylarsenic acid
Metsulfuron
Mevinphos
Monocrotophos
Nabam

Naptalam
2-(1-Naphthyl)acetic acid
(2-Napthyloxy)acetic acid
Nicosulfuron
Nicotine
Omethoate
Oxamyl
Oxydemeton-methyl
Paraquat
Pentachlorophenol
Perfluidone
2-Phenylphenol
Phosfolan
Phosphamidon
Picloram
Piproctanyl
Primsulfuron
Propamocarb
Sodium chlorate
Sodium fluoride
Sodium fluoroacetate
Sulfometuron
2,4,5-T (2,4,5-trichlorophenoxy)-acetic acid
2,3,6-TBA (2,3,6-trichloro-benzoic acid)
TCA (trichloroacetate)
TEPP (ethyl pyrophosphate)
Thiameturon
Thiocyclam
Triasulfuron
Trichlorfon
Triclopyr
Validamycin
Vamidothion

Within the above general type of compounds, or those specifically named, there are compounds with melting points greater than 100°C such as sulfonyl ureas or imidazolyl compounds. These compounds may additionally comprise the lipophilic soluble substance within the broadest definitions of this invention.

Additional pesticidal compounds which may also be mentioned for use as the lipophilic pesticidal substance, the water soluble pesticidal substance or the suspended solid pesticidal substance (i.e. for suspoemulsions whether or not the melting point of the suspended solid substance is greater than or less than 100°C) are, for example, the following:

2-(4-Morpholinocarbonyl)5-iodo-3-(3,4-dimethoxyphenyl)benzothiophene
2-(4-Morpholinocarbonyl)5-amino-3-(3,4-dimethoxyphenyl)benzothiophene
2-(4-Morpholinocarbonyl)5-(propen-2-yl)-3-(3,4-dimethoxyphenyl)benzothiophene
2-(4-Morpholinocarbonyl)-3- (4-methoxyphenyl)benzothiophene
3-(3,4-Dimethoxyphenyl)-2-morpholinocarbonylindenone
2-Morpholinocarbonyl-3-(3,4-dimethoxyphenyl)-6-methoxyindene
2-(3,4-dimethoxyphenyl)-4- (4-flurophenyl)benzoic acid
Ethyl 2-(3,4-dimethoxyphenyl)-4-(4-fluorophenyl)benzoate
N-[2-(3,4-dimethoxyphenyl)-4-(p-tolyl)benzoyl]morpholine
2-(3,4-dimethoxyphenyl)-4-(4-p-tolyl)benzoic acid
Ethyl 4-bromo-2-(3,4-dimethoxyhenyl)benzoate
Ethyl-4-amino-2-(3,4-dimethoxyphenyl)benzoate
N-[2-(3,4-dimethoxyphenyl)-6-phenylnicotinoyl]morpholine
2-(3,4-dimethoxyphenyl)-6-phenylnicotinic acid
N-[5-(4-chlorophenyl)-2-(3,4-dimethoxybenzoyl)-5-nicotinoyl]morpholine

2-(3,4-dimethoxyphenyl)-6-(p-chlorophenyl)-3-morpholinocarbonylpyridine
2-(3,4-dimethoxyphenyl)-6-(p-isopropylphenyl)-3-morpholinocarbonylpyridine
2-(3,4-dimethoxyphenyl)-6-(p-fluorophenyl)-3-methylethylaminocarbonylpyridine
2-(4-chlorophenyl)-4-(3,4-dimethoxyphenyl-5-morpholinocarbonylpyrimidine
2-(3,4-dichlorophenyl)-4-(3,4-dimethoxyphenyl)-5-morpholinocarbonylpyrimidine
4-(3,4-dimethoxyphenyl)-2-methylthio-5-morpholinocarbonylpyrimidine
4-(3,4-dimethoxyphenyl)-2-(4-methylphenoxy)-5-morpholinocarbonylpyrimidine
4-(3,4-dimethoxyphenyl)-2- (benzylthio)-5-morpholinocarbonylpyrimidine
4-(3,4-dimethoxyphenyl)-2-(3-chloro-4-fluoroanilino)-5-morpholininocarbonylpyrimidine
N-[4-(3,4-dimethoxyphenyl)-2-methyl-6-phenylnicotinoyl]morpholine
N-[2- (3,4-dimethoxyphenyl)-6-(4-fluorophenyl)-3-furoyl]morpholine

In regard to the suspended solid pesticidal substances, they are typically present in amounts up to about 500 g/l, preferably about 50 to about 500 g/l. They will generally have low or limited solubility in either the oil and water phases and may have a melting point less than or greater than 100°C, more generally greater than 100°C. More specific examples of suspended solid pesticidal substances which are useful for the preparation of the suspoemulsion compositions of the invention are, for example:

HERBICIDES

AMETRYN
Amitraz
Ancymidol
Asulam
Atrazine
Aziprotryne
Benazolin
Benoxacor
Bensulfuron
Bentazone
Benzthiazuron
Bromobutide
Bromofenoxim
Carbetamide
Clomethoyfen
Chlorflurenol
Chloridazon
Chlorimuron
Chlornitrofen
Chlortoluron
Chloroxuron
Chlorsulfuron
Chlorthal
Cinosulfuron
Clomeprop
Cyanazine
2,4-D acid
Diamuron
Dalapon acid
2,4-DB acid
Desmedipham
Dicamba
Dichlobenil
Dichlorophen acid
Difenoxuron
Diflubenzuron
Diflufenican
Dimefuron
Dinoterb
Diphenamid
Diuron
Eglinazine
Fenuron
Fluometuron
Flomesafen
Glyphosate acid
Hexaflumuron
Imazamethabenz
Imazapyr
Imazaquin
Imazethapyr
Inabenfide
Isoproturon
Isouron
Isoxaben
Isoxapyrifop
Lenacil
MCPA acid
MCPB acid
Mefluidide
Methabenzthiazuron
Methazole
Metoxuron
Metribuzin
Metsulfuron
Nicosulfuron
Phenmedipham
Picloram
Primisulfuron
Prometryn
Propazine
Propyzamide
Pyrazolynate
Pyrazosulfuron
Quinclorac
Quinmerac
Quinoclamine
Simazine
Sulfometuron
Tebuthiuron
Terbacil
Terbumeton
Terbuthylazine
Terbutryn
Thidiazuron
Thifensulfuron
Thibencarb
Triasulfuron
Tribenuron
Triflumuron

FUNGICIDES

BENZISOTHIAZOLE
Anilazine
Azaconazole
Benalaxyl
Benomyl
Bitertanol
Blasticidin-S
Captafol
Captan
Carbendazim
Chinomethionat
Chloroneb
Chlorothalonil
Chlozolinate
Cymoxanil
Cyproconazole
Diclone
Diclobutrazol
Diclomezine
Dicloran
Dimethomorph
Diniconazole
Dithianon
Drazoxolon
Ethirimol
Fenarimol
Fenpiclonil
Ferbam
Ferimzone
Flusulfamide
Flutriafol
Folpet
Hexachlorobenzene
Hexaconazole
Iprodione
Maneb
Mancozeb
Mepanipyrim
Mepronil
Methasulfocarb
Metsulfovax
Penycuron
Pentachlorophenol
Prochloraz
Pyroquilon
Quintozene
Tebuconazole
Tecloftalam
Tetrachlorophthalide
Thiabendazole
Thiphonate-methyl
Thiram
Triadimenol
Triazoxide
Tricyclazole
Triforine

INSECTICIDES

- ACRINATHRIN
- ALDICARB
- ALDOXYCARB
- Azamethiphos
- Azinphos-ethyl
- Azocyclotin
- Bendiocarb
- Brodifacoum
- Bromacil
- Bromadiolone
- Bromethalin
- Cadusafos
- Carbaryl
- Carbofuran
- Carbosulfan
- Chloralose
- Chloramben
- Chlorfluazuron
- Chlorophanicone
- Clofentezine
- Coumachlor
- Coumatetralyl
- Cyhexatin
- Cyromazine
- Diafenthiuron
- Difenacoum
- Diphanicone
- Flucycloxuron
- Flufenoxuron
- Hydramethylnon
- Teflubenzuron
- Tetradifon
- Thiodicarb

Among the surfactants, particular mention is made of nonionic surfactants which are the result of reaction of at least one mole of alkylene oxide, especially propylene oxide or ethylene oxide, with an organic compound

containing at least six carbon atoms and one active hydrogen atom. These organic compounds include phenols and aliphatic alcohols, mercapto compounds such as dodecyl mercaptan, oleyl mercaptan and cetyl mercaptan, thiophenols and thionaphthols, carboxylic , acid amides, sulphonamides, and compounds called PLURONICS, as described in US 2,674,619.

It is generally desirable to employ products containing at most 30 moles of alkylene oxide (especially ethylene oxide) per residue of the above mentioned organic compound.

Among the surfactants referred to above, preference is given to:

– The products of addition of ethylene oxide to an alkylphenol: The alkylphenols contain one or more alkyl radicals attached to the phenol nucleus, the total number of carbon atoms in the alkyl chain(s) ranging from 7 to 24, the preferred alkylphenols being those which contain 1 or 2 alkyl groups, each containing 7 to 12 carbon atoms. These alkylphenols also include the methylenephenols obtained, for example, by condensing phenols with formaldehyde. A particularly advantageous example is the product of condensation of 1 to 20 ethylene oxide units with nonylphenol;

– The products of addition of ethylene oxide to a condensation product obtained by attaching compounds containing phenolic hydroxyl groups to compounds containing olefinic double bonds and carbon rings: The following may be mentioned as representing such condensation products: mono(l-phenylethyl)phenol, di(l-phenylethyl)phenol, tri(l-phenylethyl)phenol, diphenylisopropyl phenol, mono(l-phenylethyl)cresol, (l-phenylethyl)naphthol and dicyclohexylphenol. It will be noted that the l-phenylethyl functional group is commonly called the styryl functional group. The condensation products may be subjected to the alkoxylation in the form of single bodies, but it is also possible to employ them in the form of mixtures, such as are commonly obtained in the addition by linking.

Among these, preference is given to mono-, di- or tri(l-phenylethyl)phenols or, more commonly called, styrylphenols.

All these surfactants are well known to a person skilled in the art. By way of example, reference can usefully be made to French Patent No. 1,395,059, granted on March 1, 1965, no limitation being implied.

Nevertheless, within the scope of the present invention, it is preferred to choose an emulsifying system made up of two nonionic surface-active agents, one having hydrophilic properties and the other lipophilic or hydrophobic properties. Particularly preferred amongst the hydrophobic surfactants are those which have a low HLB (hydrophilic-lipophilic-balance) and can act to prevent or inhibit crystal growth of a lipophilic active ingredient. This is best achieved when the hydrophobic surfactant mixes with and/or solubilizes in the active ingredient to significantly lower the melting point thereof. Especially advantageous for this use are the hydrophobic ethoxylated nonylphenol surfactants described above.

Thus, among the surface-active agents referred to above there are chosen, in the case of the hydrophilic agents, those which contain at least 7 alkylene oxide units; whereas surface-active agents containing fewer than 7 alkylene oxide units are chosen in the case of lipophilic surface-active agents.

In addition to this basic composition, it is advantageous to incorporate an anionic surfactant like sulphonic acids, such as long-chain alkylbenzene-sulphonates, optionally in the form of amine or ammonium salts. For example, ammonium dodecylbenzenesulphonate is advantageously employed. With reference to the composition described above, between about 0 and 10 g/litre, preferably about 2 to 10 g/litre of the anionic surfactant is employed.

In order to lower the solidification point of the emulsion and, consequently, to promote the pourability of the composition, it is also possible to incorporate one or more plasticizing diols such as ethylene glycol, propylene glycol, glycerol, di- or tri- or tetraethylene glycol, in a quantity which usually varies between about 0 and 50 g/l, with reference to the composition defined above.

It is also possible to incorporate in the compositions according to the invention all kinds of other ingredients and especially antifoam agents such as a silicone oil (silicone oil-silica mixture), certain alcohols or phenols which have few ethoxy units, biocidal agents such as citric, propionic and benzoic acids, or their salts or esters, in a quantity which usually vanes between about 0 and 50 g/l with reference to the composition defined above.

In addition to the above mentioned constituents, the compositions according to the invention may contain up to about 50 g/l of thickeners.

Thickeners are products which, when added to the emulsions according to the invention, impart pseudoplasticity properties to them. The thickeners which may be employed in the invention may be inorganic and/or organic in nature. As a thickener of an inorganic type there may be mentioned attapulgites, bentonites, caponites and colloidal silicas. As a thickener of an organic type there may be mentioned hydrophilic biopolymers of the heteropolysaccharide type of a thickening character, water-soluble polymers such as celluloses, methyl cellulose and acrylic derivatives, and vinylpyrrolidone.

The hydrophilic biopolymers of the heteropolysaccharide type which may be employed in the invention are known products. They have a molecular weight higher than 200,000 and preferably higher than 1,000,000; they

have pseudoplasticity properties and are generally obtained by the action (i.e. by fermentation) of bacteria of the genus Xanthomonas on carbohydrates. These biopolymers are also sometimes referred to by a variety of other expressions such as: Xanthomonas hydrophilic colloids, heteropolysaccharide resins, xanthan resins, extracellular heteropolysaccharides onginating from Xanthomonas or from bacteria of the Pseudomonadaceae family. The word biopolymer is employed to mean that a polymer originating from a biological process (bacterial fermentation in this case) is involved.

The bacteria employed for the preparation of these biopolymers are in most cases Xanthomonas campestris, but it is also possible to employ other Xanthomonas such as Xanthomonas carotae, Xanthomonas incanae, Xanthomonas begoniae, Xanthomonas malvacearum, Xanthomonas vesicatoria, Xanthomonas translucens or Xanthomonas vasculorum. Suitable carbohydrates for fermentation with the aid of suitable carbons for the fermentation, with the aid of Xanthomonas bacteria are glucose, sucrose, fructose, maltose, lactose, galactose, starch, potato starch, etc.

Other adjuvants which may also be employed with the emulsions of this invention are penetrating, wetting, or translocating promoting agents. Such agents may additionally have properties referred to as bioactivation. Examples of these are: ethoxylated tallow amine; ethoxylated diamine; glycerine; sorbitol; polyethylene glycol; ammonium sulfate; linear alcohol ethoxylate; nonylphenol ethoxylate; dioctyl sulfosuccinate; alcohol ether sulfates; and organosilicone surfactants, such as SILWET L-77, or polyalkylene oxide modified dimethyl polysiloxane copolymers.

The above oil-in-water concentrated emulsions may be prepared by any convenient method, but are preferably prepared by a) the combination of the hydrophobic nonionic surface-active agent with a mixture of the lipophilic pesticide and solvent as required and then b) the combination of the resulting lipophilic mixture with the aqueous phase containing the hydrophilic surfactant, the dispersing agent and the water soluble pesticide. This last stage is accompanied by stirring to form the emulsion. An emulsion of more mediocre quality is obtained when the nonionic surface-active agent(s) (emulsifiers) are added to the aqueous phase in the emulsion-forming step.

The addition may also be performed using a reverse method. This means placing the oily phase in the aqueous phase and this is an additional advantage of titanium dioxide. The emulsion obtained is next homogenized by various methods to form a macroemulsion.

One method of homogenization consists of employing an efficient disperser or a bead mill or a colloid mill or an APV Gaulin-type plunger homogenizer to obtain a macroemulsion with a droplet size of appropriate diameter (average diameter in the range of about 1-8 microns and an overall size distribution in the range of about 1-15 microns).

The pesticidal emulsions according to the invention are used by dilution with water so as to obtain an effective pesticidal composition. For example, all of these emulsions can be applied for the control of pests, as stable O/W emulsified spray mixtures, etc., whereby the concentrated emulsion is diluted from about 10 to about 200 fold with water. For application to crops for example, a final spray mixture may be generally applied at a rate in the range of about 100 to about 1200 litres per hectare, but may be higher or lower (e.g., low or ultra-low volume) depending upon the need or application technique.

As already briefly mentioned in the preamble of the description, emulsions such as just described can lead to excellent suspoemulsions by addition of a solid pesticidal substance which is then milled by means of a mill. These suspoemulsions are especially useful in the case of mixtures with, for example, carbaryl or thiodicarb.

The examples below illustrate the invention:

The following **EXAMPLES 1-7** of titanium oxide stabilized oil-in-water macroemulsions, specifically as herbicidal combinations, were prepared containing several pesticidal active ingredients to exemplify the invention wherein the oil phase contains one or more lipophilic active ingredients and the aqueous phase contains one or more water soluble (hydrophilic) active ingredients. These concentrate compositions, as well as others described within the scope of this invention, can be readily diluted with water to give stable sprayable compositions at concentrations suitable for use in field applications as previously described. The components/ingredients which were used in these formulations are listed below by their generic chemical descriptions.

Common/Trade Name	Chemical Description
A. Active Ingredients, A.I.	
Glyphosate IPA	N-(phosphonomethyl)glycine isopropylamine salt
2,4-D TIPA, 75%	(2,4-dichlorophenoxy)acetic acid tris(2-hydroxypropyl)amine salt
2,4-D IOE, 90%	(2,4-dichlorophenoxy)acetic acid isooctyl ester
2,4-DP IOE, 90%	(2,4-dichlorophenoxy)propionic acid isooctyl ester
2,4-D DMA, 75%	(2,4-dichlorophenoxy)acetic acid dimethylamine salt
Bromoxynil octanoate, 92%	2,6-dibromo-4-cyanophenyl octanoate
Bromoxynil heptanoate, 93 %	2,6-dibromo-4-cyanophenyl heptanoate
B. Adjuvants	
TENNECO 200	C_{10}-C_{13} aromatic hydrocarbons, solvent
TENNECO 500/100	mixed xylenes and C_9 + solvent naphtha, solvent
SILWET L-77	polyalkylene oxide modified silanes, bioactivator
SOPROMINE S30	ethoxylated (20 EO) tallow amine, wetting/penetrating agent

Propylene glycol	1,2-propanediol, antifreeze agent
ATLAS G 3300	dodecylbenzenesulfonic acid amine salt, anionic dispersing/emulsifying agent
GERONOL 724P	ethylene oxide/propylene oxide block co-polymer (EO:PO 70:30), emulsifier
SAG 30	silicone, antifoam
ATTAGEL 50	attapulgite clay, thickener/diluent
METHOCEL E50LV	hydroxypropyl methyl cellulose, thickener
CARBOPOL 910	acrylic acid polymer, thickener
BIOZAN	xanthan gum, thickener
TiO_2 DuPont R100	titanium dioxide, rutile form of 0.2-0.3 micron particle size, dispersing/stabilizing agent.

The general procedure used for the preparation of these concentrated compositions utilized the actual technical active ingredient or as is adjuvant weights in g/l and was as follows:

a. A homogeneous oil-phase was prepared by thoroughly mixing the oil-phase active ingredient(s) and optionally, if necessary, a solvent, e.g., TENNECO 200 or also optionally, if necessary, a hydrophobic surface active agent.

b. A homogenous water-phase was prepared by thoroughly mixing the water-phase active ingredient(s) and adjuvants: e.g., propylene glycol (antifreeze/pourability agent): GERONOL 724P (emulsifier, previously melted at 50°C); ATLAS G3300 (dispersing/emulsifying agent); Glyphosate IPA (technical active ingredient as a 62% aqueous solution); 2,4-D TIPA (technical active ingredient as an aqueous solution); SOPROMINE S30 (wetting and penetrating agent); SAG 30 (antifoam agent); water (carrier); TiO_2 (stabilizing/dispersing agent); and ATTAGEL 50 (clay diluent/thickener). While these ingredients were preferably added in this sequence, the order can generally be that which is convenient and maintains the water-phase homogeneity; in this regard, the propylene glycol is best added before the GERONOL 724P. As required, the pH of the aqueous phase may be adjusted now or after mixing in part c). A preferred pH is generally in the range of about 4 to about 7-8 and is obtained by addition of about 0.1 N NaOH or HCl.

c. The oil-phase was gradually added to the well stirred water-phase and made up to one liter by adding water if necessary. The addition may also be performed in a reverse method. This mixture was then homogenized by passing it through a homogenizing mixer, e.g., a bead mill with 1-1.5 mm Zicor beads. These final oil-in-water emulsions were determined to have an average particle size of the dispersed oil droplets of about 2-8 microns; more preferably 3-5 microns; an overall size distribution was in the range of 1-15 microns. Good to excellent stability of these emulsions was confirmed in extended time and high temperature studies as described below.

Example 1

The following emulsion was produced (in g/l):

- 2,4-D IOE	176	} oily phase
- 2,4-D TIPA	299	
- Glyphosate IPA	182	
- SOPROMINE S30	100	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 2

The following emulsion was produced (in g/l):

- 2,4-DP IOE	208	} oily phase
- 2,4-D TIPA	325	
- Glyphosate IPA	90	
- SOPROMINE S30	50	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	50	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 3

The following emulsion was produced (in g/l):

- 2,4-D IOE	191	oily phase
- 2,4-DP IOE	208	
- Glyphosate IPA	90	
- SOPROMINE S30	50	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	50	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 4

The following emulsion was produced (in g/l):

- 2,4-D IOE	352	} oily phase
- Glyphosate IPA	182	
- SOPROMINE S30	100	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 5

The following emulsion was produced (in g/l):

- Bromoxynil octanoate	107	oily phase
- Bromoxynil heptanoate	106	
- TENNECO 200	80	
- Glyphosate IPA	180	
- SOPROMINE S30	100	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	50	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 6

The following emulsion was prepared (in g/l):

- Bromoxynil octanoate	71	oily phase
- Bromoxynil heptanoate	71	
- TENNECO 200	40	
- 2,4-D DMA	337	
- Glyphosate IPA	122	
- SOPROMINE S30	50	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	50	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 7

The following emulsion was prepared (in g/l):

- Bromoxynil octanoate	71	oily phase
- Bromoxynil heptanoate	71	
- 2,4-D IOE	235	
- TENNECO 200	40	
- Glyphosate IPA	122	
- SOPROMINE S30	50	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	50	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO2 R-100	10	
- Balance of water up to 1 litre		

Example 8

Stability Test

The compositions are subjected to various stability tests. For example, the following provides the stability results on compositions of **Examples 3**, **4** and **5** with TiO_2, as compared to equivalent compositions without TiO_2. It is quite apparent that TiO_2 as a dispersing and stabilizing agent provides surprising and unexpected good to excellent (exc.) stability vs. poor-fair without TiO_2.

The compositions are typically subjected to one or more of the following stability tests:

– First, these compositions are subjected to five cycles of uniform temperature variations during five weeks from - 10°C to 35°C.

– Second, these compositions are placed for one month in an oven at 50°C.

– Third, these compositions are placed at 35°C for three months.

For example, the compositions of Examples 3-5 were stored for one month at 50°C after which the following tests were conducted and results obtained.

	Composition Example No.					
	3		4		5	
	TiO_2	no TiO_2	TiO_2	no TiO_2	TiO_2	no TiO_2
Separation (%)	8.2	26.5	4.3	32.9	9.7	42
Resuspension Quality	exc.	poor	exc.	fair	good	poor
Dispersion Quality (Bloom) (in 100 ml tap H_2O)	good	fair	good	fair	fair	poor
Number of Inversions To Suspend	3	6	2	6	4	9

In a similar manner to that described above for **EXAMPLES 1-8**, other oil-in-water emulsions, can be prepared and tested using other water soluble active ingredients, oil- soluble active ingredients and suspended solid active ingredients, such as those described in the preceding lists.

These examples can include compounds such as:

- Acifluorfen sodium: 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid sodium salt;
- Dichlorophen sodium: 5,5′-dichloro-2,2′-dihydroxydiphenylmethane;
- Glyphosinate ammonium: 4-[hydroxy(methyl)phosphinoyl]-DL-homoalanine ammonium salt;
- Imazaquin ammonium: 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2yl)quinoline-3-carboxylic acid ammonium salt;
- Imazaquin: as the acid form in the oil phase;
- Imazapyr IPA: 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid isopropylammonium salt;
- Imazapyr: as the acid form in the oil phase;
- Metsulfuron: 2-[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)ureidosulfonyl benzoic acid methyl ester, which optionally may be as a water soluble salt depending upon the pH adjustment by a neutralizing agent;
- Pendimethalin: N-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine; or
- Chlorsulfuron: 1-(2-chlorophenylsulfonyl)-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)urea, which optionally may be as a water soluble salt depending upon the pH adjustment by a neutralizing agent.

Examples of these are as follows:

Example 9

The following emulsion is produced (in g/l):

- Bromoxynil octanoate	142	oily phase
- Bromoxynil heptanoate	142	
- TENNECO 200	40	
- 2,4-D DMA	415	
- Propylene glycol	30	
- ATLAS G 3300	5	
- GERONOL 724P	50	
- SAG 30	1.5	
- ATTAGEL 50	15	
- METHOCEL E50LV	2	
- TiO_2 R-100	1.2	
- Balance of water up to 1 litre		

Example 10

The following emulsion is prepared (in g/l):

- 2,4-D IOE	250	} oily phase
- Acifluorfen sodium	250	
- Propylene glycol	50	
- ATLAS G 3300	5	
- GERONOL 724P	30	
- SAG 30	1	
- CARBOPOL 910	1	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 11

The following emulsion is prepared (in g/l):

- 2,4-D IOE	350	} oily phase
- Dichlorophen sodium	200	
- Propylene glycol	50	
- GERONOL 724P	40	
- ATLAS G 3300	5	
- SAG 30	1	
- Carboxymethyl cellulose	1	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 12

The following emulsion is prepared (in g/l):

- Bromoxynil octanoate	150	} oily phase
- Glyphosate IPA	270	
- Acifluorfen sodium	150	
- SOPROMINE S30	10	
- Propylene glycol	5	
- GERONOL 724P	30	
- SAG 30	0.5	
- ATTAGEL 50	10	
- BIOZAN	2	
- TiO_2 R-100	11	
- Balance of water up to 1 litre		

Example 13

The following emulsion is prepared (in g/l):

- Bromoxynil octanoate	100	oily phase
- Bromoxynil heptanoate	100	
- SILWET L-77	100	
- TENNECO 500/100	80	
- Glufosinate ammonium	350	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 14

The following emulsion is prepared (in g/l):

- Bromoxynil octanoate	100	oily phase
- Bromoxynil heptanoate	100	
- SILWET L-77	100	
- TENNECO 500/100	80	
- Metsulfuron	50	
- Dichloromethane	70	
- Glyphosate IPA	225	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 15

The following emulsion is produced (in g/l):

- 2,4-D IOE	180	oily phase
- 2,4-DP IOE	180	
- SILWET L-77	100	
- Metsulfuron	50	
- Dichloromethane	70	
- Glyphosate IPA	70	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 16

The following emulsion is prepared (in g/l):

- Pendimethalin	135	oily phase
- TENNECO 500/100	80	
- Glyphosate IPA	135	
- SOPROMINE S30	100	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 17

The following emulsion is prepared (in g/l):

- Chlorsulfuron	25	oily phase
- SILWET L-77	100	
- Dichloromethane	100	
- Imazaquin ammonium	225	
- Glyphosate IPA	170	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 18

The following emulsion is prepared (in g/l):

- Metsulfuron	25	oily phase
- SILWET L-77	100	
- Dichloromethane	100	
- Imazapyr IPA	175	
- Glyphosate IPA	140	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	
- Balance of water up to 1 litre		

Example 19

The following emulsion is prepared (in g/l):

- Pendimethalin	150	oily phase
- SILWET L-77	100	
- TENNECO 500/100	80	
- Glufosinate ammonium	350	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	

- Balance of water up to 1 litre.

Example 20

The following emulsion is prepared (in g/l):

- Imazaquin	225	oily phase
- Chlorsulfuron	25	
- SILWET L-77	100	
- TENNECO 500/100	100	
- Dichloromethane	25	
- Glyphosate IPA	170	
- Propylene glycol	30	
- ATLAS G3300	5	
- GERONOL 724P	40	
- SAG 30	1.5	
- ATTAGEL 50	15	
- TiO_2 R-100	10	

- Balance of water up to 1 litre.

The above oil-in-water emulsions can also be made into suspoemulsions where an additional solid pesticidal substance(s) is suspended in the composition. Examples of these may be as follows:

Example 21

The following suspoemulsion (suspended thiodicarb) is produced (in g/l): technical thiodicarb, N,N'- [thiobis [(methylimino)carbonyloxyl]]bis[ethanimidothioate], (92%, 163 g) is dispersed with stirring in a mixture containing:

- acephate, N-[methoxy(methylthio)-phosphinoyl]acetamide	70
- 7:1 ethylene oxide/polyaryl-phenol sulphate condensate (7 EO)	25
- complex phosphoric ester	25
- ethylene oxide/nonylphenol poly-condensate with 2, 7 and 10 EO (1:1:1)	80
- deodorizer, salicylate	10
- attapulgite	20
- titanium dioxide in anatase form	20
- antifoam	5
- balance water up to 1 litre	

A dispersion of solid in water is therefore obtained. For the oil phase, technical ethion, S, S'-methylene-bis(O,O-diethyl phosphorodithioate), (96%; 391 g) is then added and a homogeneous suspoemulsion, is obtained, which is milled in a bead mill.

Example 22

The following suspoemulsion (suspended carbaryl) is produced (in g/l) under the same conditions as above:

- technical ethion, 96%, S,S'-methylenebis-(O,O-diethylphosphorodithioate)	261}	oily phase
- technical carbaryl, 92%, 1-naphthalenyl methylcarbamate	229	
- phosfolan, 2-(diethoxyphosphinylimino) 1,3-dithiolan	50	

- 7:1 ethylene oxide/polyaryl-phenol sulphate polycondensate (7 EO) 50
- ethylene oxide/nonylphenol polycondensate with 2, 7 and 10 EO (1:1:1) 85
- deodorizer, salicylate 10
- attapulgite 15
- titanium dioxide in anatase form 30
- balance water up to 1 litre

Example 23

The following suspoemulsion (suspended 2,4-D acid) is produced (in g/l) under similar conditions as above:

- 2,4-DP (BEE)	255}	oily phase
- Glyphosate IPA	196	
- 2,4-D (Acid)	142	
- SOPROMINE S30	50	
- Propylene glycol	30	
- GERONOL 724P	30	
- SAG 30	2	
- ATTAGEL 50	5	
- TiO_2 R-100	20	
- Balance of water up to 1 litre		

Example 24

Similarly the following suspoemulsion (suspended Isoproturon) is produced:

- 2,4-D IOE	100}	oily phase
- 2,4-D Na	100	
- Isoproturon [3-(4-isopropylphenyl)-1,1-dimethylurea]	500	

- Ethoxylated phosphate ester	20
- Nonylphenol ethoxylate	5
- ATLAS G3300	40
- Propylene glycol	30
- GERONOL 724P	30
- SAG 30	2
- ATTAGEL 50	5
- TiO_2 R-100	20
- Balance of water up to 1 litre	

Example 25

Similarly the following suspoemulsion (suspended atrazine) is produced:

- Bromoxynil octanoate, 94% 2,6-dibromo-4-cyanophenyl octanoate	133	
- Bromoxynil heptanoate, 94% 2,6-dibromo-4-cyanophenyl heptanoate	133	oily phase
- Diflufenican, N-(2,4-difluorophenyl)-2-[3-(trifluoromethyl)phenoxy]-3-pyridinecarboxamide	50	
- TENNECO 200	30	
- Glyphosate IPA	90	
- Atrazine, 6-chloro-N-ethyl-N′-(1-methylethyl)-1,3,5-triazine-2,4-diamine	330	
- Ethoxylated phosphate ester	25	
- Nonylphenol ethoxylate	5	
- ATLAS G3300	40	

- Propylene Glycol	30
- GERONOL 724P	30
- SAG 30	2
- ATTAGEL 50	5
- TiO_2 R-100	20
- Balance of water up to 1 litre	

In the various above macroemulsion composition examples, the dispersed oil droplet particle size is typically as follows:

Average Size, microns	about 1 to about 8
90% < Size, microns	about 2 to about 13
General Distribution Size, microns	about 1 to about 15

However, the particle size can be smaller or larger within the definitions as discussed above for a macroemulsion of the present invention.

It is to be understood that although the invention has been described with specific references to particular embodiments thereof, it is not to be so limited, since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

Claims

1. A stabilized oil-in-water (O/W) pesticidal emulsion, comprising:

(a) a oil phase containing a lipophilic pesticidal substance, optionally dissolved in an organic solvent;
(b) an aqueous phase containing a compatible water-soluble pesticidal substance;
(c) an emulsifying system to emulsify or disperse the oily phase in the aqueous phase; and
(d) a stabilizing or dispersing agent comprising titanium dioxide in an effective amount to further maintain or improve the stability of the emulsion.

2. A stabilized O/W emulsion according to claim 1, wherein the lipophilic pesticidal substance has a melting point below about 100°C.

3. A stabilized O/W emulsion according to claim 2, wherein the lipophilic pesticidal substance has a melting point within the range of temperature variation to which that substance is subjected, during storage or preparation of the emulsion.

4. A stabilized O/W emulsion according to claim 3, wherein the range of temperature variation during storage or preparation of the emulsion is between about -20°C and about +60°C.

5. A stabilized O/W emulsion according to any one of the preceding claims, wherein the titanium dioxide is present in a proportion of about 1 g/l to about 100 g/l of the emulsion.

6. A stabilized O/W emulsion according to claim 5, wherein the titanium dioxide is present in a proportion of about 5 g/l to about 50g/l of the emulsion.

7. A stabilized O/W emulsion according to claim 1, comprising in grams/litre:

(a) a lipophilic pesticidal substance which has a melting point below 100°C or which has melting point within the range of temperature variation to which that substance is subjected during storage: 100

to 80
(b) the organic solvent 0 to 350
(c) a hydrophobic surface-active emulsifying agent 0 to 100
(d) a hydrophilic surface-active emulsifying agent 20 to 60
(e) the compatible water-soluble pesticidal substance 20 to 600
(f) the titanium dioxide-based dispersing or stabilizing agent 1 to 100
and
(g) water balance to 1,000.

8. A stabilized O/W emulsion according to any one of the preceding claims:
(a) which is a macroemulsion with the oil phase containing the lipophilic pesticidal substance, in which the average oil droplet particle size is between about 2 and about 8 microns and further with a particle size distribution between about 1 and about 15 microns; and
(b) which has the titanium dioxide stabilizing or dispersing agent as a fine powder present in a proportion of about 1 g/l t about 100 g/l of the emulsion and with an average particle size in the range of about 0.1 micron to about 1 micron.

9. A stabilized O/W emulsion according to claim 8, wherein the titanium dioxide powder:
(a) is in a proportion of about 10 g/l to about 30 g/l; and
(b) has an average particle size from about 2% to about 50% of the average oil phase droplet particle size.

10. A stabilized O/W emulsion according to claim 9, wherein the average particle size of the titanium dioxide powder is in the range of about 0.2 to about 0.3 microns.

11. A stabilized O/W emulsion according to claim 10, wherein the titanium dioxide powder has a hydrophilic surface.

12. A stabilized O/W emulsion according to any one of the preceding claims, wherein:
(a) the oil phase lipophilic pesticidal substance is phosalone, oxadiazon, aclonifen, linuron, bifenox, alachlor, ethoprofos, bromoxynil octanoate or heptanoate, ethion, 2,4-D isooctyl ester, 2,4-DP isooctyl ester, metsulfuron, pendimethalin or chlorsulfuron or a mixture thereof; and
(b) the water phase, water-soluble pesticidal substance is a glyphosate salt, a 2,4-D salt, acifluorfen salt, a dichlorphen salt, a glufosinate salt, an imazaquin salt or an imazapyr salt or a mixture thereof.

13. A stabilized O/W emulsion according to claim 12, wherein the lipophilic pesticidal substance is: a mixture of bromoxynil octanoate and heptanoate, containing from about 100 to about 600 g/l of the mixed esters, based upon bromoxynil phenol; a mixture of aclonifen and linuron; or 2,4-D isooctyl ester or 2,4-DP isooctyl ester or a mixture thereof.

14. A stabilized O/W emulsion according to claim 12, wherein the water soluble pesticidal substance is glyphosate isopropylamine salt, 2,4-D triisopropylamine salt or 2,4-D dimethylamine salt or a mixture thereof.

15. A stabilized O/W emulsion according to any one of the preceding claims, which further comprises other additives selected from antifoam agents, antifreeze agents, thickening agents, wetting agents, penetrating agents, translocating agents, and bioactivating agents.

16. A stabilized O/W emulsion according to any one of the preceding claims, which further comprises a suspended solid pesticidal substance obtained by mixing and milling the emulsion and the solid to provide a stable suspoemulsion.

17. A stabilized O/W emulsion suspoemulsion according to claim 16, wherein the suspended solid pesticidal substance is present in an amount from about 50 to about 500 g/l of the emulsion.

18. A stabilized O/W emulsion or suspoemulsion according to any one of the preceding claims, wherein said emulsion or suspoemulsion is diluted with water to provide a diluted and stabilized O/W emulsion or suspoemulsion composition.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0294

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	EP-A-0 342 134 (RHONE-POULENC AGROCHIMIE) ---		A01N25/04
A D	FR-A-2 171 239 (FARBWERKE HOECHST AG.) & US-A-3 873 689 -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			A01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 FEBRUARY 1992	DONOVAN T.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
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